Education for the Talented in Mathematics and Science

A Report of a Joint Conference of the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science and the United States Office of Education

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Contents

	Page
Foreword	iv
Introduction	1
I. Who Are the Talented in Mathematics and Science?	2
II. The Need for the Talented in Science and Industry	2
III. Ways of Identifying the Talented	3
Instruments (Tests)	3
Informal Methods	5
IV. Providing for the Talented in Science and Mathematics	6
Organisational Provisions	6
Classroom Activities	10
Out-of-class Activities	13
Guidance Procedures	15
Physical Facilities	16
V. Evaluation and Summary	18
Bibliography	25
Appendix	29
Program of the Conference	29
Conference Participants	30

Foreword

EDUCATION FOR THE TALENTED IN MATHEMATICS AND SCIENCE will be of interest to guidance counselors, school administrators, supervisors, directors of teacher education, curriculum coordinators, and laymen who desire to strengthen secondary school instruction for talented students. Since science and mathematics teachers were special contributors to the bulletin, there is much of value to classroom teachers in these fields. The problems associated with identifying students with potential and providing opportunities for their development are numerous. Suggestions for dealing with these problems in certain fields will also be helpful in other areas. This suggests that the ideas revealed in this bulletin will be useful to a large number of educators working at elementary, secondary, and college levels of instruction.

The Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science that participated in planning for and publishing this bulletin is composed of representatives of seventeen national scientific and mathematical societies including representatives from the associated teaching organizations. The Committee has been seeking the improvement of science and mathematics teaching in secondary schools for about two decades.

In 1947 the Committee prepared a treatise on the effectiveness of the schools in the training of scientists. The report, issued as an appendix to *Manpower for Research*, volume four of Science and Public Policy, appraised mathematics and science teaching in grades 1–12 as well as in institutions of higher learning. Recommendations looking toward the strengthening of weaknesses were given. Many of the recommendations are of high pertinence today largely because they were not heeded 5 years ago.

Since 1949 the Committee has been holding its fall meeting with interested staff members of the Office of Education. Beginning in 1950 this fall meeting has been the occasion for a conference of leaders concerned about scientific personnel and ways to bring about desirable training programs. In 1951 the conference emphasized the place of high-school instruction in alleviating the shortage of specialized personnel for industry and defense.

The fall conference of 1952 focused attention on the identifying of high-school students with potential for science and mathematics and providing opportunities for their development. Our critical shortage of leaders for all fields suggests that special attention should be given to all youth in our

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schools and especially to our talented youth. This report with emphasis on science and mathematics is of special pertinence today because of the importance of scientific research to discover new basic truth and to design and manufacture new products for defense and progress.

The report was prepared from addresses and discussions at the conference by Kenneth E. Brown, Specialist for Mathematics, and Philip G. Johnson, Specialist for Science.

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Education for the Talented in Mathematics and Science

Introduction

THE PUBLIC SCHOOLS are dedicated to the task of providing opportunities for the maximum educational development of each pupil. If there is no discrimination, each student, from the slow learner to the rapid learner, from the most talented to the least talented, will have those educational experiences that will permit him to become of maximum worth to himself, to his community, and to society. In harmony with the purposes of education in a democracy is the important task of identifying and making provisions for the student with exceptional potential in each of the fields of learning.

The present struggle for the very existence of our freedoms causes the need for the improvement of the instruction in science and mathematics to become increasingly important. This was recognized by a conference held at the U. S. Office of Education, November 13–15, 1952. The theme of this conference was "Ways of Identifying and Providing for the Student with Potential in Science and Mathematics."

More than one hundred educators,[1] including leaders in Government and industry contributed to the conference through the presentation of short papers [2] and participation in group discussions. Members of the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science served as observers and provided a summary of each group discussion.

The present brief report is a résumé of the special papers and the contributions from seven discussion groups. Many ideas were expressed by more than one individual and discussed by more than one group. At times exact statements seem to be distorted when taken out of context. For these and other reasons, this report contains no quotation marks, and no one person is given credit for any specific part. However, all the ideas came from the members of the conference. The statements may vary slightly from those expressed by the contributors, but care was taken to avoid any distortion of the ideas. As Montaigne, the French philosopher said, "I have gathered a nosegay of flowers in which there is nothing of my own but the string that ties them."

[1] See Appendix, pp. 30–34.
[2] See titles of papers. Appendix, pp. 29–30.

I. Who Are the Talented in Mathematics and Science?

The talent necessary for success in mathematics or science may, on the one hand, be due to some special inherited ability. Without this ability the pupil may find mathematical learnings difficult. On the other hand, the requirement for success in mathematics or science may be high general intelligence plus the proper learning environment. Perhaps there is no single ability for mathematics or science potential. Science or mathematics potential is more likely to consist of a complex pattern of primary abilities. However, the question is an academic one because the teachers in most schools do not have the time or facilities to seek out illusive single abilities, if they exist. They can identify the student with high general intelligence who seems apt and interested in science and mathematics.

For the purpose of this discussion, the talented and rapid learners in mathematics and science will be interpreted to mean the pupils who are among the upper 20 percent of the students in general intelligence and who seem to be apt in science and mathematics. These students will usually show high accomplishment in science and mathematics courses, but may not have high grades in such courses due to lack of proper motivation and instruction.

II. The Need for the Talented in Science and Industry

A SHORTAGE OF SPECIALIZED PERSONNEL

The technological advances of the world during the last decade have been made possible by the increasing number of specialists. Reports indicate that both the United States and USSR have doubled their supply of technical specialized personnel during this period. If advances in medicine, the humanities, and the sciences are to continue at the present rapid rate, the supply of specialized personnel must expand. It is reported that the present annual output of engineers and technicians in the USSR is approximately 100,000 with prospect for rapid expansion. The outlook is not the same for the United States. Present evidence indicates that the supply of scientists and engineers in the United States will not continue to expand at the same rapid rate.

Our engineers and scientists for the next few years must come from the graduating classes in our colleges. There is not enough manpower in our colleges to meet needs now seen. It is true the number graduating in 1950 was more than double the figure for 1940. However, this increase was abnormal due to the influx of GI's. The present graduating class is approximately three-fourths of the number graduated in 1950. Basing estimates on the population reaching college age and the normal increase in persons going to college, it seems fairly certain that for the next few years the supply of scientists and engineers cannot increase as it has during the past 5 years. Yet the survival of our democratic way of life may depend upon our increased technological progress. The battle for the freedoms we

so fondly cherished may be lost in the laboratory. Our supply of engineers and scientists already is getting dangerously low.

A Manpower Supply That Can Be Tapped

There is a potential source of scientists and mathematicians that needs to be tapped. Only 40 percent of the high-school graduates of college ability are granted a college degree. What happens to the other 60 percent? What happens to this large pool containing many potential scientists and engineers? Twenty percent drop out during college, and 40 percent never enter college. Why do 40 percent of our capable youth fail even to enter college? It was reported that of the capable graduates of the Minnesota high schools who were not going to college 50 percent stated that they did not have the money. Other reports indicate the foremost reason for the failure of these potential scientists, engineers, and leaders of our Nation to undertake college studies is lack of money. Another significant reason is a failure to appreciate the importance of college studies. Here inadequate motivation and guidance may be the basic reasons.

We are spending large sums of money to develop our material resources and at the same time fail to develop a large part of our human resources. We spend millions of dollars for stockpiles of critical minerals, but we spend little to increase our supply of the most vital instruments of defense—the scientists. We should make a special effort to provide better opportunities for the rapid learner in our high schools and, through proper guidance and financial aid, prepare the capable students for leadership in the area in which he can be of most value to himself and society. Is it not time that we stop wasting our human resources and develop to a maximum the youth of our Nation?

III. Ways of Identifying the Talented Student in Mathematics and Science

To facilitate the reading of this report, a separation is made between identifying the student and providing for his development. However, in many cases, the talents become evident only when opportunities are provided for their development.

INSTRUMENTS FOR IDENTIFYING POTENTIAL IN SCIENCE AND MATHEMATICS

Standardized tests are frequently used to help identify the rapid learners in mathematics and science. They are especially helpful in identifying the superior child who is recitation shy or who has a language handicap. Such tests also bring into proper perspective the pupil who appears talented by comparison to retarded classmates. To be most effective as a guidance instrument, the tests should measure depth as well as breadth in understanding and knowledge. Success in quantitative reasoning is the single factor most

closely related to success in training for science, engineering, and related careers. Mere tests of knowledge, such as the ability to recall formulas or standard processes, do not reveal the potential scientist as well as tests that require reasoning in solving problems. Those who use achievement tests in identifying the able student in science and mathematics should study carefully the available tests to avoid those that emphasize merely recognition or recall of time-honored information.

Verbal comprehension is the second most significant factor to test for in identifying students with potential in mathematics and science. The student must be able to read to become a scientist.

Mechanical reasoning tests help to further identify the potentially able student in science.

Abstract reasoning tests which measure the ability to interpret relationships among diagrammatic materials have met with success when used in addition to the other tests indicated above.

Spatial visualization tests give additional assistance in identifying the talented student in science, engineering, and mathematics. Spatial visualization is necessary for success in descriptive geometry, surveying, and engineering drawing, which are required in most curricula of colleges of engineering.

Interest tests are of secondary importance in locating the potential scientists. Although potential scientists and mathematicians are likely to be interested in problems in that area, all those who have the interest may not have the ability. Interest may be faked, and it is unstable in adolescents. It would seem wise, therefore, to consider school grades and other data from the student's cumulative record in interpreting scores from interest tests.

In all these tests, power tests are preferable to speed tests. Ability to solve difficult problems seems to be a better predictor of scientific success than speed in solving simple ones.

No One Test Is Adequate

It was emphasized at the conference that caution should be used in attempting to identify the student with potential in science and mathematics by the measurement of any single ability. Most students superior in either reasoning ability or verbal ability are above average in the other. However, many studies have shown that there are students of ordinary verbal ability who do superior work in mathematics, while some students of superior verbal ability have a disability in mathematics.

Teachers have found that tests including sections on both quantitative reasoning and verbal comprehension are to be preferred to a single measure I. Q. test. In any case, test results along with the student's total cumulative record give the best evidence for identifying the students with potential in mathematics and science.

INFORMAL METHODS OF IDENTIFYING THE STUDENT WITH POTENTIAL IN MATHEMATICS AND SCIENCE

Teacher's opinion is of value in identifying the talented in mathematics and science. Evidence of superiority is often colored by student friendliness, obedience, and attractiveness. Completing routine assignments perfectly may be mistaken as a sign of high potential in science or mathematics. Creativeness of the student and conformity to inflexible regulations are hard to reconcile. Special interests of superior students may even hinder achievement in unchallenging school subjects. Although investigators have reported that attempts of teachers to identify the future leaders in science were correct in only 15 cases in 100, it does not mean that teachers' opinions are of no value or that they cannot be improved. Teachers can improve their judgment by observing many informal criteria that indicate aptness in mathematics and science. Keeping a record of their predictions and, after the student has left college, checking the predictions with his achievement would be helpful in improving predictive techniques. If the records indicated in detail the criteria used in making predictions, they would be valuable to future teachers.

Although our present supply of reliable criteria is limited, teachers have found certain characteristics of pupils that indicate potential in science and mathematics.

1. Extraordinary memory seems to indicate a capacity for superior learning. A boy who in the senior year of high school could give at sight the square of any number between 1 and 100 or the senior girl who could repeat extensive information concerning the planet Jupiter based on her studies in the ninth grade are examples of students with extraordinary memories.

2. Intellectual curiosity is often indicated by a persistence in asking questions and an eagerness to investigate marginal content, which usually challenges only those who are intellectually mature.

3. Ability to do abstract thinking may be revealed by unusual insight into probable discrepancies and by skill in formulating hypotheses from new data.

4. Ability to apply knowledge to other situations is found in superior students. A student who selects formulas and principles appropriate to a new situation and evaluates the results is exhibiting such ability.

5. Persistence in worth-while behavior is a characteristic common to leaders in science. It is reported that Edison worked continuously for 72 hours while working on the wax record. After he was 80 years of age, he began the study of botany. He tested thousands of plants for rubber in the remaining 4 years of his life. A scientist does not give up easily. This type of perseverance should not be confused with aimless plodding.

6. Insight into abstractions is found to an extraordinary extent in the scientist and mathematician. Many teachers have had students in their classes who always seemed to see the answer before the problem was com-

pletely stated. A student in geometry was asked to describe the figure formed by joining consecutively the midpoints of the sides of a quadrilateral. He gave the correct answer in a few seconds and immediately asked what figure would be formed by joining the midpoints of the sides of any polygon. Such insight is rare.

Characteristics such as extraordinary memory, intellectual curiosity, persistency, insight into abstractions, the ability to do abstract thinking on a high level, the ability to translate data into generalizations, and the ability to apply knowledge to new situations have been used successfully by many teachers in identifying the student with outstanding ability in science and mathematics.

Cumulative Record—An Aid in Identifying the Able Student

The criteria for informally identifying students with potential in science and mathematics should be used in conjunction with other information in the student's cumulative record. For example, in one school where special attempts are being made to identify superior students, the cumulative record folder of a student contains I. Q. scores, a profile chart, a detailed elementary school record, anecdotal records of the student's behavior in class and out of class, scores on tests in verbal comprehension, English, mathematics, mechanical ability, space perception, and interests. A folder of this kind used by a competent teacher will be very helpful in identifying and intelligently guiding students into appropriate professions and occupations.

IV. Providing for the Talented in Science and Mathematics

Many types of provisions are now being made for talented students. Some of these provisions are largely matters of organization, guidance, and physical facilities. In other cases the provisions are almost entirely the responsibility of the classroom teachers. In fact, there can be no effective substitute for enthusiastic, well-informed teachers who know the needs of talented students and who also know how to guide the students in appropriate activities. In making provisions for the superior students, the teachers need books and pamphlets for supplementary study, time and facilities for preparing instructional material, time for student counseling and individualized instruction, and equipment for meaningful learning activities. A program of this type needs full support of administrators.

ORGANIZATIONAL PROVISIONS FOR THE TALENTED

Special Schools

A separate school is one organizational method used in providing better educational opportunities for the talented student. The talented student is challenged by working with other students of similar ability; he seems to meet the challenge with increased effort.

In very large cities special schools have been set up to provide the educational opportunities that are the right of each boy and girl. To provide the maximum development of each boy and girl, schools have been established for the deviates—the talented and the student of little talent. New York City, Baltimore, Philadelphia, and Cincinnati operate special schools for talented and rapid learning students. Studies of their graduates give many indications of well-rounded superior adults.

Other cities point with pride to graduates of a special high school within a high school. Instruction in such high schools is often concerned with general education in the lower high-school grades and specialization in the upper grades.

Special Classes

A special class is another organizational method used to provide improved opportunities for the rapid learner. For example, one school selected 25 ninth-grade students who seemed to be talented in mathematics. One teacher was assigned to this group for their 4 years of high school. The students of this honor class were given special privilege, but they assumed special responsibility.

Special classes permit the intensive study of topics that are adapted to the ability of the student at a challenging rate and in a stimulating atmosphere. In a class of this type in New York, many pupils take an abstract approach to mathematics. Every pupil is encouraged to read a supplementary book and to prepare a written report on some special topic. The activity method of teaching prevails with pupils demanding more work than a teacher would be expected to assign to them.

An interesting course is now being given to a special class in a high school in West Virginia. The course consists of content selected from the fields of plane geometry, algebra, trigonometry, analytic geometry, and differential and integral calculus which is taught to a selected group of tenth-grade pupils. The success of the course has caused a similar course to be offered this year to students in the eleventh grade, and a twelfth-grade course is planned for next year.

The method of providing special classes for superior students seems to be popular especially in large high schools. A study of California public high schools, that seem to be unusually successful in developing outstanding students in science and mathematics, disclosed that one-fourth of the schools with an enrollment of more than 500 provided special classes for the superior students. In selecting the students for these classes, the schools considered previous marks, recommendations of teachers, student's interests, and intelligence quotient.

Aside from assigning pupils to the proper sections, two other practical problems should be met in an ability-grouping plan. In the first place, the teachers should be satisfied with their assignment; and, second, it should be possible for pupils to transfer from one type of section to another both

during the year and from one year to the next. Under these conditions all sections in a given course will study the same basic content with enrichment materials used in the sections for the rapid learners.

Ability Grouping—A Fundamental Idea

The idea of grouping students of like ability is not a new one. When the first one-room school became a two-room school, the more advanced students were placed in one of the rooms and the other room was reserved for the less advanced. It was soon discovered that better instruction could be provided as the range in abilities became less. As numbers increased in the two-room school, it became a three-room school. Again the division was based on student ability and achievement. As the number of children increased, so did the number of rooms, with the division based on the advancement of the student.

The two-track plan, a form of ability grouping, is used by many high schools. If the size of the freshman class in high school is adequate for two sections, a division based on ability and achievement is often arranged. One section may be called arithmetic and the other algebra, or they both may bear the same title, such as General Mathematics or Mathematics I, but the content and instruction are geared to a level appropriate for the students. Many schools have this two-track plan at the ninth grade for mathematics and sometimes for science. A few schools attempt with success a three-track plan in ninth-grade mathematics. Some schools offer consumer mathematics and college algebra—a two-track plan for the seniors; other schools offer applied mathematics and trigonometry for the juniors—a two-track plan; but very few schools have a two-track plan for the full 4 years.

Ability grouping is sometimes postponed until the students have had a semester of exploratory work. For example, during the first term in a biology class special efforts are made to identify the students with potential for science. The identified students are invited to enter a special biology section during the second term. This special section then becomes a special class for science students with high abilities which permit them to progress rapidly in science. In some schools the students of the special section may continue as a special section the following year. In such cases the students are challenged to undertake special projects for science contests and to make the unusual progress which their abilities make possible.

Acceleration

Acceleration is one of the oldest methods of providing for the development of the talented. In fact, it is one of the widely used methods today. Perhaps it can be used to a greater degree with high-school students with less social maladjustment than in the elementary school. Some teachers experienced with the acceleration method think that a pupil may be accelerated as much as 2 years ahead of his normal age group without developing serious problems in social adjustment.

For several years acceleration has been practiced in a Minnesota community by permitting superior students to complete the work of the seventh and eighth grades in 1 year. In fact, groups of these accelerated students have now been graduated. No undesirable personality traits appear to have developed. In accelerating students to groups beyond their age level, it seems important that the student associate with others of similar social maturity. Perhaps the social development of the student should receive a greater consideration than the chronological age in determining student acceleration. It was emphasized at the conference that enrichment of the student's program is usually to be preferred to student acceleration.

Variable Student Load

Greater educational opportunities are sometimes provided for the talented by permitting them to enroll in additional courses. In small high schools extra subjects may be taken by the supervised correspondence study plan. The extra student load procedure is easy to administer, and it is frequently used. Although it permits the student to explore an additional field of learning, it may usurp a free period that he could use more profitably in interests that may be and should be aroused during the school year.

Supervised Work Experiences

Talented students often serve as helpers to the teacher. For example, seniors may receive valuable experience as laboratory assistants. Other talented students may work in the school store, cafeteria, school office, and library. The rapid learners may be given work permits for part-time jobs in the community. To be most effective, the supervised work experience should be an exploratory one in the area of the student's interest. Through such experiences the student will be able to gain a depth of knowledge concerning a chosen vocation which will permit him to make an intelligent vocational choice.

Individualized Instruction

The administrational and organizational procedures in some schools encourage individual instruction. The instruction may be on an individual basis for all the students in a particular grade. For example, in one Minnesota community, individual instruction is the method employed in the seventh and eighth grades. Individualized instruction also may be used with only a few students in teaching certain topics. In either case, it provides the opportunity for the talented to work at a rapid rate and discourages laziness that comes from assuming the slow pace of the less talented. Individualized instruction with project work, laboratory exercises, and field trips can be used in small high schools as well as in large high schools. Talented students can work on high-school correspondence courses in physics, chemistry, and mathematics as a part of their individual work and thus gain needed information even though the school does not have such courses

in their program of studies. Teachers using the method of individual instruction state that it requires organized units that are largely self-instructive and a testing program that is largely self-administering. It should be well organized with adequate material. We are warned that even then the end results probably will be acceleration with emphasis on skills. However, it would seem desirable that the organization of instruction should permit and provide for individual instruction where and when needed rather than on an entire grade or school basis.

CLASSROOM ACTIVITIES FOR THE TALENTED

The classroom provisions for the rapid learner refer to the procedures that are primarily the responsibility of the teacher and under his direct supervision. They are types of instruction in which the teacher, regardless of organizational provisions, may use to improve the educational development of the talented. However, for these procedures to be most effective the teachers need the full support of the administrators.

Read and Write Activities

The most common classroom procedure could be called the read and write method. The student reads some material in a book or magazine and then writes a report, or he studies some problems in a book and writes the solution.

The organizing and planning in connection with this method vary greatly. It may be, on the one hand, only general encouragement of the students to read something bearing on the general topic of class discussion and to report when the students desire. Students may be given the opportunity to solve supplementary drill problems with little recognition for the extra work. On the other hand, the special information to be gathered may be a part of the general class task. The material to be read may have been selected as the result of cooperative planning by teacher and student. The written report may be supervised by his English teacher and evaluated by the class. Recognition may be shown to the student by the publication of the best reports in the school paper.

The read and write method can provide many worthwhile opportunities for the talented to develop their potentials in science and mathematics. However, to be of maximum benefit, the material to be read should be the result of cooperative planning by the student and teacher. The material should be within the ability of the student, but challenging. It should contribute to the objective of the general class activities. The superior student and the other members of the class should be aware of and see the importance of the material in relation to the class activity. The class and the student reporting should evaluate the contribution of the project to the class. If the contribution is superior, recognition should be given.

Recognition can be given in many ways:

(1) Approval of the student's work by teacher and classmates.
(2) Exhibit of student's work in room or hall.
(3) Student's work shown to principal, other teachers, specialists in the area, and parents.
(4) Publication of student's material in school paper.
(5) Publication of student's material in newsletters for teachers.

The appropriate method is determined by the teacher who knows the background of the student and the local environment. In any case, pupils desire recognition for a job well done.

Some educators have concluded that since some read and write methods involve only general encouragement of all students to do supplementary problems or answer questions, the method has little value. Although the method represents a relatively easy way of providing for the talented student, it does not have to be a vague and unplanned procedure. Teachers have found by following the principles just stated that the read-and-write method can be a valuable aid to instruction of the superior child.

Class Projects

The project method seems to be a very popular and useful method for providing additional educational opportunities for the superior child.

A class project is usually a rather comprehensive activity which contributes to the general objective of the class. The project may be one to show the use of algebra in everyday affairs or the effect of diet upon the physical development of youth. It may involve gathering information from books, magazines, and specialists. Experiments may be performed to obtain the necessary data. Models or murals may be constructed to illustrate the ideas involved. The project may require the gathering of statistical data from the community and assistance from lay persons for its interpretation. Results of the project may be evaluated by the teacher and students. The project may be of such nature and scope that it will be helpful for the parents and the school administrators to take part in the appraisal.

The following criteria seem to be valuable guides in appraising a class project:

(1) The project should contribute to the general objective of the class, and the students should understand its place in the educational purposes of the class. Perhaps teacher-pupil planning will assist here.
(2) All the students should receive valuable learning experiences.
(3) The relation of organized knowledge to the solution of life problems should become more evident to the student.
(4) The project should assist in building desirable attitudes in students.
(5) The project should be a contribution by the entire class and not the work of an ambitious minority.

(6) The evaluation of the project should contribute to the educational development of the students and lead to better planned and more worth-while activities.

Teachers have found that classroom projects properly planned and carried out are helpful and challenging to the superior child in extending applications of his basic knowledge.

Small-Group Projects

In the case of individual or small-group projects, as the title indicates, the entire class does not contribute. However, the project should be directly related to the class purposes. For example, the concern of the class may be in an understanding of the basic elementary ideas of probability. One of the superior students may, during a teacher-pupil planning conference, decide to make a probability board. From this experience he may extend and more firmly fix the ideas of probability (the general class topic) in his own mind and his explanation of the project to the class may motivate and encourage other students.

At one school students formed utility squads. For example, a small group of students were organized in a "Biology Squad." The purpose was to maintain a supply of live specimens for the high-school laboratory. The actual accomplishments of the "Biology Squad" far exceeded its original purpose. It has brought both motivation and increased knowledge to the students.

In providing for extra activities for the rapid learner in science and mathematics, many teachers have found individual or small-group projects exceedingly valuable. The wide range in interest of superior students requires that the teacher be familiar with many appropriate projects. However, it is fortunate that the literature in the teaching of science and mathematics contains suggestions for many successful projects. The following projects illustrate the variety and range of difficulty of projects that are being successfully used by classroom teachers:

(1) Construction of models.
(2) Construction of laboratory apparatus.
(3) Demonstration of an experiment.
(4) Collection of statistical data from school or community and interpreting it to the class.
(5) Construction of teaching aids, such as a stylus for construction of second degree curves.
(6) Mural showing the development of measurement.
(7) Script for mathematics or science assembly.
(8) The importance of a specific idea in mathematics expressed in a poem.

Student Participation in Teaching Activities

Occasionally teachers have permitted a superior student to participate in the conduct of the class. The time which is required by both teacher and

student to prepare for student instruction of the class prevents many superior students from having this experience. It is without doubt an excellent method of interesting students in the possibilities of teaching as a career. Some teachers have given superior students experience in planning, with the teacher, class activities and ways of evaluating class progress. This procedure seems to stimulate the better students. It provides a better perspective of the course, as well as familiarizes the student with the problems of teaching. Experience as an assistant in the mathematics or science laboratory has been helpful in permitting the superior student to gain experiences beyond those of the classroom. One teacher in New York City who has been unusually successful in helping superior students indicates that the laboratory is kept open by assistants each hour of the day for students who are working on approved individual projects. This provides an excellent opportunity for both the assistant and superior students to develop under their own initiative. Similar procedures are reported in Denver and Minneapolis.

A frequently used method of increasing the educational experience of the superior child is to permit him to assist other students in the classroom. If the method is used in moderation, it is a desirable experience for the superior student. However, if the coaching is confined to one area of knowledge and to that with which the superior student is quite familiar, the point of diminishing returns is soon reached. It is a method that requires careful planning if desirable results are to accrue to both the tutor and the one being taught.

Group Work Within a Class Recommended

In the classroom or individual projects just described, the provision for the superior student to coach other students is used most frequently. However, teachers indicate that the more desirable single method is group work within a class. The entire class works toward a common goal, but small groups within the class will explore more deeply into certain phases of the common topic. This challenges the talented student to read and explore, and the results of the superior student's findings can contribute to the learning experiences of the entire class. Teachers have indicated that in a democracy we expect the specialist not only to dig deeply into his area of special interest, but also to contribute his knowledge to the welfare of society. The procedure of encouraging the superior students to work individually or in groups on special projects and contribute this enrichment material to the class certainly is education in desirable lifelike situations.

OUT-OF-CLASS ACTIVITIES FOR THE TALENTED

An out-of-class activity, of the type discussed at the conference, has the following characteristics: (1) It is planned and developed out of class; (2) the activity does not contribute directly to the class purposes at the time; and (3) it is supervised by the teacher.

Mathematics or Science Clubs

The most frequently used out-of-class activity is the mathematics club and science club. The club usually meets during the school day; specialists from the community may assist the students. For example, in one community in North Carolina, the Engineers Club of the city contributed greatly in the establishment and development of an Engineers Club in the high school. The engineers have furnished printed guidance material, speakers, and publicity material for the Career Day. The Rotary Club of a Pennsylvania community contributed to the success of Career Day in their local schools by providing engineers and scientists from the club to give vocational guidance. The students' questions and the answers of the specialists were mimeographed for reference during the year. Other professional science and mathematics groups have contributed to the success of clubs in a similar manner. In a New York community the school clubs meet during the evening. Membership is entirely voluntary, and work on individual projects is stressed. Teachers receive extra pay for working with the club program. Many local citizens give time and materials to aid the students. Teachers have found that the clubs provide an excellent opportunity for the talented to explore important areas of interest and become familiar with adults in various areas of specialization.

Contests and Exhibits

Contests and exhibits have been beneficial in stimulating talented students to develop their potential abilities in science and mathematics. The Mathematics Tournament sponsored by the Wilson Junior College of Chicago is a contest that has been received with favor by the teachers. The contest among the students of several public high schools is composed of eight relays of ten problems each. Awards go to the four highest schools and to the six highest individuals. Teachers are honored as well as students.

In Louisiana, seven colleges offer scholarships to incoming freshmen who are winners in district and State contests. The students receiving the two highest scores in the State contest and the student receiving the top score in each of the district contests receive scholarships.

Similar contests are sponsored by the Los Angeles City College, Interscholastic Mathematics League of New York City, Pi Mu Epsilon of New York University, the New York Section of the Mathematical Association of America, and the University of Chicago.

The student and teacher awards of the Future Scientists of America Foundation, the Science Talent Search by the Westinghouse Educational Foundation, Essay Contests by the American Chemical Society, and other contests also give students opportunity to develop talents in mathematics and science.

To assist the teachers in the local public high schools, scientists and engineers in a Georgia community prepared in 1952 a list of suggested topics that were appropriate for the Science Talent Search. The names of special-

ists who were willing to assist and guide students in exploring these projects were included.

Fairs and Conferences

Teachers report that Science and Mathematics Fairs have encouraged many students to develop talents in science and mathematics. A recent Science Fair included students' mathematics projects in linkages, geometric drawings, polyhedrons made of various materials, a mechanical device for solving quadratic equations, cycloids, and devices for determination of pi.

Conferences for superior pupils in mathematics and science seem to stimulate interest.

To guide the superior student in preparing for worth-while out-of-class activities requires teacher and student time. Teachers need to be given time for this important type of instruction to our talented pupils. We spend a tremendous amount of out-of-school time for athletics, provide special coaches with extra salary, and buy expensive equipment for the athletically talented. Is it not time similar provision be made for the students who are talented in other ways?

GUIDANCE PROCEDURES FOR THE TALENTED

The full-time guidance counselor has an important task of coordinating guidance procedures and supplying valuable consultative services. However, the success of a guidance program in a high school depends on the teachers. Competence in guidance requires a thorough knowledge of the student, familiarity with current sources of guidance material, and a fine working relationship with other persons concerned with the student.

In many schools the homeroom teacher or classroom teacher bears the major responsibility in guiding and counseling the students. Although there is a great need for more nearly adequate guidance, the teachers are making progress. In the light of the little knowledge they have of each of their many students and the little time they have for counseling each student, they are doing a remarkable job.

Guidance Materials

Guidance material has proved to be very valuable in making provisions for the rapid learner in mathematics and science. City and county educational directors have secured vocational guidance material in science and mathematics from higher educational institutions such as Purdue University, University of Illinois, Georgia Institute of Technology, Tulane University, Duke University, and University of Florida. These materials are made available to teachers and students for counseling and guidance purposes.

Career Days

Many high schools have provided one or more days each year which are devoted exclusively to guidance. Representatives of colleges inform the

students of college demands and opportunities. Leaders in industry and professions discuss the talents needed for success in their various fields. The concentrated periods of guidance may be called Career Days or Career Clinics, but in any case the purpose and procedures are similar—namely, to help the student make a more intelligent choice of future activities by the counsel received direct from specialists. In one New York high school, the special annual guidance day is called "Student Conference on Higher Education." The conference, which has been held for seven consecutive years, includes discussion groups concerned with opportunities for further education of the student, and a "College Problems Clinic for Parents Only."

Community Consultants

Some schools have increased this opportunity for expert guidance and help from one or two designated days a year to those times at which guidance is needed by the student. For example, the public-school administrators of one city in Georgia found by means of a questionnaire the persons in industry and education who were willing to help and guide the superior students. The list of these persons, with the area in which they were most familiar, was available to the teachers. If a student became interested in taxidermy on October 13, he did not have to wait until Career Day, May 18, to talk with a specialist in that area. The teacher could make an appointment for the student with the taxidermist while the interest was keen. The specialist assisted the student in planning an exploratory project which would give an insight into the student's field of interest. Such timely guidance requires careful planning by the administration and the understanding cooperation of lay persons.

Tests as Guidance Aids

A file of current standardized tests available to teachers and students is a valuable aid to guidance. With but little aid from the teacher, the superior student can administer and score his own test to determine the extent of his knowledge in a certain area.

After a student had determined his percentile rating on a mathematics test he was heard to remark "I didn't know as much about that as I thought I did. I guess I'll study some more on that." The teacher and student alike are inclined to estimate the ability of a student in terms of his classmates. It has been said that a moron among imbeciles appears to be a genius. A comparison of the student with several thousand other students by means of a standardized test may clarify an otherwise distorted picture of his ability. Certainly a true picture of the student's ability is needed by student, teacher, and parent in planning for his future.

PHYSICAL FACILITIES

The types of instructional procedures mentioned in the foregoing sections

require enriched as well as flexible physical facilities.[8] Enriched because the rapid learner can achieve mastery of the normal study materials at a rapid rate and the students should progress to more penetrating problems or technical experiments. Flexible because the talented are competent to proceed with the activity of greatest promise following a period of group and individual planning with the teacher.

Adequate laboratories, classrooms, and teaching material are not confined to the large high schools. In fact, in many small schools the barren mathematics classroom of the last century has been changed to a mathematics laboratory. It has become a room in which students, by experimenting, collect data and interpret it in the language of mathematics. The results of their applications of mathematics are found on the bulletin boards and display tables. The different physical facilities are indicative of differential learning experiences and should be provided if proper opportunities are to be given the talented student to develop. The room of 1900 with 40 seats securely fastented to the floor and surrounded by a chalkboard will not meet the needs of the present American youth any better than the horse and buggy will meet the transportation needs of modern civilization.

For desirable learning to take place, the students and teacher should have physical facilities for the following activities:

(1) A period for planning by teacher and student. Such activity is vital to the proper motivation and guidance to the student.

(2) Careful reading of background material in the area to be explored and discussed. Adequate reference material to accommodate reading that may be broad in scope or intensive in terms of a specific field or topic should be accessible at the time needed.

(3) Collection of data. This may include reading in books and magazines, performing of experiments, and studying the community or school.

(4) Verification and interpretation of data. This may be done by experiments, by expressing generalizations in mathematical terms, by group discussion, and by making models.

(5) Evaluation and applications. Group evaluation helps the student understand the place of the topic being studied in relation to the purposes of education. This concept is necessary for meaningful education to take place. Applications of the unit may result in written papers, talks, murals, poetry, designs, construction of teaching devices, and demonstrations of experiments or carefully solved problems.

These activities cannot take place if the physical facilities are limited to fixed desks and a chalkboard. The lecture-type room is no longer adequate for either science or mathematics instruction. Provision should be made in both science and mathematics for student experimentation, planning and

[8] Johnson, Philip G., *and committee.* Science Facilities for Secondary Schools. Washington, U. S. Government Printing Office, 1952. (Federal Security Agency, Office of Education, Misc. No. 17).

evaluating discussions by small groups of students, supplementary books and magazines, construction of models and teaching devices, project material, drawing and exhibit materials, computing devices, work tables, and storage for supply materials. For mathematics to be meaningful to students, they should have concrete experience in using both mathematical ideas and skills in life situations. Without the proper physical facilities, such as those just outlined, adequate learning experience for the talented as well as for all students is difficult, if not impossible, to provide.

Once minimum requirements concerning size and provision of facilities have been met, the greatest factor limiting the development of provisions for superior science and mathematics students is the unwillingness of administrators to allow special rules to be applied to the special situations created by the presence of these students in the school.

In particular, the rigid enforcement of rules regarding student supervision, which is based on the concept that students are irresponsible children, constitutes a serious handicap in many situations—particularly in schools that are part of large systems. With the exception of very small schools, the advantages of increased size seem to be offset by the increased administrative rigidity that comes with bigness.

Administrators of some high schools, both large and small, have contributed greatly to the education of the talented in mathematics and science by providing (*a*) adequate physical facilities, (*b*) ability grouping (such as the two-track plan), (*c*) abundant source of enrichment material, (*d*) flexible organizational regulations which permit independent activities by small groups of students, (*e*) student guidance coordination, (*f*) adequate parent informational service, and (*g*) teachers qualified by both preparation and temperament. Such provisions are needed in all schools in order for teachers to develop leaders in mathematics and science needed by our Nation in times of war and peace.

V. Evaluation and Summary

Attempts to evaluate our success in providing opportunities for the superior student in mathematics and science have been meager. The supply of scientists and engineers since 1940 has approximately doubled. Our schools have produced persons who have greatly extended the frontiers of scientific knowledge. What caused these men to become scientists? What procedures and techniques encourage and cause students to develop their abilities in mathematics and science? Teachers respond that it is such activities as mathematics clubs, projects, individualized instruction, talented teachers, special classes, adequate counseling, acceleration, and group work. When students in Minnesota were asked, they gave such answers as:

"It wasn't the frosting; that is, the puzzles, tricks, or unusual problems that stimulated me, it was the meaning of the process."[1]

"My teacher was the key to my interest and attainment in mathematics."

"Receiving a letter for continuous appearance on the honor roll was a tremendous incentive."

"* * * a teacher who fostered independence and self-study."

Perhaps each of the procedures that have been discussed has enriched the educational experience of some pupils. Many schools have done a good job. However, many capable young people are not motivated either to work to capacity while in high school or to continue their academic education. One out of three of our capable high-school graduates never enters college. What can we do to help develop this valuable national resource? Briefly outlined below are some of the activities of others. Perhaps as they are read many areas in which research is needed will be recognized and ways to improve practices will occur to the reader.

What Some Administrators Are Doing

1. Selecting teachers who are especially prepared both by training and by temperament for the training of the talented pupil.
2. Developing flexible regulations that permit appropriate activities for the best development of the superior student.
3. Reducing the classload of teachers of deviates—both slow and rapid learners.
4. Organizing a flexible two- and three-track plan for the full 4 years.
5. Providing more nearly adequate physical facilities such as rooms with work tables, display boards, teaching aids, supplementary books, storage space, and supplementary teaching material.
6. Using ability grouping when enrollments permit.
7. Encouraging teachers to attend workshop and in-service training courses concerned with methods of improving the instruction for the talented.
8. Developing an improved information service for the parents in order that they may understand the provisions that are being made for the superior child.
9. Assisting teachers in locating specialists who can and will provide information and guidance on how to serve the talented pupil.
10. Providing teachers with adequate free time to prepare and plan instruction material for the superior student.

What Some State Departments of Education Are Doing

1. Providing specialists in the teaching of mathematics and science.
2. Providing library loan service of books, tests, learning aids, motivation material, guidance material, and lists of free and inexpensive teaching aids.
3. Providing workshops that will give teachers methods and techniques for teaching superior students.

4. Acting as a clearinghouse for new and successful methods and techniques for identifying and providing for the student with potential in science and mathematics.
5. Sponsoring research and experimentation for evaluating procedures used with the talented student.
6. Providing special help in planning laboratories, and other physical facilities suitable for superior students.

What Some Teacher-Training Institutions Are Doing

1. Providing scholarships for talented students.
2. Giving prospective teachers experiences in teaching the talented.
3. Providing courses in how to teach the talented.
4. Sponsoring summer workshops which emphasize instruction of the talented.
5. Providing consultative services to schools in regard to the development of the talented.
6. Providing in-service programs during the school year for teachers.
7. Providing teaching aids and guidance materials.
8. Sponsoring special days for guidance purposes such as College Career Day.
9. Encouraging and promoting research in mathematics and science education.
10. Providing an open house or conference for high-school students.

What Some National Organizations of Education Are Doing

1. Publicizing the importance of providing better opportunities for the talented students in mathematics and science.
2. Sponsoring organizations of students who are interested in science and mathematics.
3. Providing scholarships for students of outstanding ability.
4. Sponsoring contests that provide awards for outstanding students.
5. Providing guidance service materials for teachers.
6. Selecting and distributing supplementary teaching aids.
7. Sponsoring research in mathematics and science education.
8. Developing publications on physical facilities needed for proper instruction.
9. Providing suggestions on how to assist talented students.
10. Developing long-range plans to interest talented students in scientific careers.

What Some Supervisors Are Doing

1. Encouraging the selection of teachers who are qualified both by training and temperament.
2. Assisting teachers in selecting stimulating instructional material for the talented.

3. Providing teachers with information in regard to supplementary material for their students.
4. Organizing in-service groups that study the problems of teaching the talented pupil.
5. Providing teachers' meetings that stimulate educational growth in providing for the talented.
6. Encouraging special projects for the talented.
7. Providing material and assistance in developing better mathematics clubs.
8. Providing teachers with information in the use of field trips for the talented.
9. Coordinating county, city, and State projects such as science fairs, contests, and exhibits.
10. Organizing workshops where teachers share ideas concerning methods of developing the rapid learner in mathematics and science.
11. Arranging with scientists and engineers in the community to serve as consultants to capable high-school mathematics and science students.
12. Assisting scientists and engineers in planning special programs for high-school students with interests in science and mathematics.
13. Securing consultants to assist science and mathematics teachers in improving their courses and their teaching procedures.

What Some Teachers Are Doing

1. Taking in-service courses and summer workshops to improve their instruction of the superior student.
2. Using individualized assignment plans and procedures.
3. Carefully compiling and making use of student records.
4. Stimulating the students to work in small groups of similar ability under their own initiative.
5. Stimulating worth-while individual "read and write" experiences.
6. Encouraging and supervising special projects for the talented.
7. Organizing class instruction around large ideas in mathematics and science.
8. Providing the students with standardized tests which can be student-administered and student-scored.
9. Planning class activities with the talented student.
10. Giving the superior student special privileges in routine daily work but expecting special contribution to the class.
11. Encouraging the talented to take part in science fairs, contests, and exhibits.
12. Providing the student with adequate guidance material.
13. Sponsoring clubs for science and mathematics students.

14. Giving appropriate recognition to superior work which encourages still greater accomplishments from the talented.
15. Giving the student experience in self-evaluation.

What Some Lay Persons Are Doing

1. Meeting with school groups to describe their occupation and the preparation required for employment in it.
2. Taking part in committees responsible for planning and operating Career Conference.
3. Serving as judges in contests and exhibits.
4. Providing scholarships for able students.
5. Encouraging career planning as a part of high-school activities through parent-teacher and professional committees.
6. Supporting organized school and community programs giving career information to all high-school students.
7. Serving as consultants to science and mathematics students who are working on special projects.
8. Giving consultative service to workshops for science and mathematics teachers.
9. Publicizing the need for better educational opportunities for the talented student.

What Some Industrial and Business Leaders Are Doing

1. Providing scientists, engineers, and technicians to take part in career conferences, assembly programs and class discussions.
2. Underwriting the expenses of special summer in-service programs for science and mathematics teachers.
3. Providing funds for local, State, and national programs helpful to talented high-school science and mathematics students.
4. Providing scholarships, medals, and cash awards to outstanding high-school students.
5. Providing pamphlets that describe career opportunities related to mathematics and science.
6. Assisting school leaders in developing improved facilities for mathematics and science teaching.
7. Providing films and slides that reveal how science and mathematics are used in business and industry.
8. Providing teachers with experiences in the applications of science and mathematics in industry through appropriate summer employment.
9. Providing specialists in science and mathematics as consultants for workshops for teachers.
10. Sponsoring conferences of leaders in business, industry, and education.

The preceding outline indicates some attempts being made to improve the instruction of the talented. Many other similar activities are being used.

Summary of Planning a Program for the Talented

When teachers desire to begin a special program proposed to improve the opportunities for the students with potential in mathematics and science, the cooperation of the administrators should be of primary concern. Adequate texts, supplementary books, and adequate physical facilities constitute a minimum requirement which must be met if success in providing for such students is to be possible. To obtain these facilities, the cooperation of administrators will be needed. This cooperation is usually forthcoming if a sound program has been properly presented. The average administrator knows the difficulties facing such a program much better than he knows the methods for overcoming them. A desirable way for the science or mathematics teachers to get administrative cooperation is by preparing practical plans tailored to the local school situation and discussing them with the administrators along with any requests for special consideration for the superior student.

After the cooperation of the administration is assured, pertinent information concerning the program should be channeled to the parents. The purposes and general methods of the improvement program should be common knowledge of all parents. In fact, the degree of success depends, to a large extent, on the degree to which parents, newsmen, government officials, businessmen, and ordinary citizens are informed of the need for using wisely our most precious human resources.

The maximum development toward these goals cannot be accomplished without good teachers. Teachers should have the talent to arouse curiosity and stimulate learning. They should have a pleasant personality and a genuine enthusiasm for learning. They should possess an extensive knowledge of the subject matter and children. Teachers with these requirements are available, but there is an additional characteristic that is also needed. The teacher should know the techniques and methods that can be used with the superior student. Few teachers have had instruction in this area.

A Triple Need

If teachers are to identify and provide for the students with potential in science and mathematics, the teachers need summer and in-service training. Workshops, institutes, and in-service training programs concerned with methods of instruction for the talented should be sponsored by the State departments of education, universities, and industry. To increase our standard of living and defense preparations, we need to develop more of our able youth. Our supply of leaders in science and mathematics can be increased by:

1. Education and industry cooperating in providing in-service training for teachers through workshops and conferences that are concerned with instructional methods for the talented.

2. Industry, government, and colleges providing scholarships for the able student who does not have financial support.
3. Education and industry making funds available for research to determine the best methods to use with the talented student.

Summary Statement By

The Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science

Two days after the close of the Conference, the Cooperative Committee issued the following statement:

One hundred teaching scientists and mathematicians from all parts of the country met at the United States Office of Education on November 13, 14, and 15, 1952, to consider the problem of identifying and providing for the educational needs of students with high aptitude in science and mathematics. A year ago a similar conference emphasized the importance of secondary schools in supplying the need of personnel trained in science and mathematics; since then, the Office of Defense Mobilization and reports from industries have again called attention to the continuing and increasing lack of such personnel.

It is, therefore, the sense of this conference—

1. That the proper development of such personnel is essential to the welfare of the Nation; especially so, in view of the critical shortage of scientists and engineers, the present and anticipated demands of a technological age, and the state of international tension.
2. That equality of educational opportunity is basic to democracy; and that that implies an opportunity for every individual to attain his own maximum achievement.
3. That we cannot afford to continue the resulting loss to society in high quality human resources and creative contributions.
4. That current general practices for identifying and developing students with high aptitude in science and mathematics are inadequate.
5. That many tested and successful practices are being used for the early identification and proper development of students with high aptitude. Those practices should be made widely known.
6. That schools and colleges be urged to modify administration, curricula, guidance and teaching facilities and procedures so as to facilitate the widespread use of these successful practices.
7. That inadequate educational provisions for youth of high promise cause difficulties in coordinating school and college education.
8. That teacher-training institutions and school systems give greater recognition to the need for teachers qualified to teach students of top-level ability.

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Youth—The Nation's Richest Resource, Their Education and Employment Needs. Washington, U. S. Government Printing Office, 1953. (20¢.)

Appendix

PROGRAM OF THE CONFERENCE

CONFERENCE OF THE COOPERATIVE COMMITTEE ON SCIENCE AND MATHEMATICS TEACHING (AAAS) AND THE OFFICE OF EDUCATION

Nov. 13–15, 1952, Federal Security Building (North) Washington, D. C.
Independence Avenue at Third Street SW.

THEME: IDENTIFYING HIGH SCHOOL STUDENTS WITH POTENTIAL FOR SCIENCE AND MATHEMATICS AND PROVIDING OPPORTUNITIES FOR THEIR DEVELOPMENT.

Thursday Morning—Auditorium, Federal Security Agency (North Bldg.), Nov. 13

Philip G. Johnson, Presiding

9:00 — *Office of Education Welcome to Participants*
James C. O'Brien, Assistant Commissioner of Education

9:15 — *Cooperative Committee Welcome to Participants*
Morris Meister, Chairman, Cooperative Committee

9:30 — *The Importance of the Theme*
Dael Wolfle, Commission on Human Resources and Advanced Training Washington, D. C.

10:00 — *General Ways to Identify Students With Scientific and Mathematical Potential*
Howard F. Fehr, Teachers College, Columbia University, N. Y. C.

10:30 — *Instruments That Help to Identify Students With Scientific and Mathematical Potential*
Warren G. Findley, Educational Testing Service, Princeton, N. J.

11:00 — Organization of Discussion Groups

11:30–1:00 — Lunch period

Thursday Afternoon

1:00–4:30 — Group Discussions on *INDENTIFYING* HIGH SCHOOL STUDENTS WITH POTENTIAL FOR SCIENCE AND MATHEMATICS

Room	*Discussion Setting*	*Consultants*
G–747A	Group I. What can be done in small high schools?	James H. Getty, Bala-Cynwyd, Pa. F. G. Lankford, Charlottesville, Va.
G–755	Group II. What can be done in general high schools?	Paul Klinge, Indianapolis, Ind. William A. Gager, Gainesville, Fla.
G–743A	Group III. What can be done by extra-curricular programs?	Rolland J. Gladieux, Kenmore, N. Y. Daniel Lloyd, Washington, D. C.
G–751	Group IV. What can be done on city-wide basis?	Annie Sue Brown, Atlanta, Ga. Veryl Schult, Washington, D. C.
Aud.	Group V. What can be done by grouping in high schools?	Herbert H. Reichard, Allentown, Pa. Andrew V. Kozak, Athens, W. Va.
G–759A	Group VI. What can be done in technical high schools?	Edward B. Van Dusen, Pittsfield, Mass. David Skolnik, Newark, N. J.
5542	Group VII. What can be done in specialized high schools?	Zachariah Subarsky, New York, N. Y. Nathan Lazar, Columbus, Ohio.

Friday Morning—Auditorium, Federal Security Agency (North Bldg.) Nov. 14

Kenneth E. Brown, presiding.

9:00 Comments by presiding chairman.

9:15 *Stimulating and Educating Superior Students in Mathematics.* George E. Hawkins, Lyons Township High School, La Grange, Ill.

9:45 *School Adaptations for Gifted Science Students.* G. G. Gordon, University Southern California, Los Angeles.

10:15 *School Adaptations for Gifted Mathematics Students.* Donovan Johnson, University of Minnesota, Minneapolis.

10:45–11:30 General discussions.

11:30–1:00 Lunch period.

Friday Afternoon

1:00–4:30 Group Discussions on *PROVIDING OPPORTUNITIES* FOR HIGH SCHOOL STUDENTS WITH POTENTIAL FOR SCIENCE AND MATHEMATICS

Room	*Discussion Setting*	*Consultants*
G–747A	Group I. What can be done in small high schools?	James H. Getty, Bala-Cynwyd, Pa. F. G. Lankford, Charlottesville, Va.
G–755	Group II. What can be done in general high schools?	Paul Klinge, Indianapolis, Ind. William A. Gager, Gainesville, Fla.
G–743A	Group III. What can be done by extracurricular programs?	Rolland J. Gladieux, Kenmore, N. Y. Daniel Lloyd, Washington, D. C.
G–751	Group IV. What can be done on city-wide basis?	Annie Sue Brown, Atlanta, Ga. Veryl Schult, Washington, D. C.
Aud.	Group V. What can be done by grouping in high schools?	Herbert H. Reichard, Allentown, Pa. Andrew V. Kosak, Athens, W. Va.
G–759A	Group VI. What can be done in technical high schools?	Edward B. Van Dusen, Pittsfield, Mass. David Skolnik, Newark, N. J.
5542	Group VII. What can be done in specialized high schools?	Zachariah Subarsky, New York, N. Y. Nathan Lazar, Columbus, Ohio.

Saturday Morning—Auditorium, Federal Security Agency (North Bldg.) Nov. 15

Morris Meister, presiding.

9:00 Comments by presiding chairman.

9:15–11:00 Summation and integrated reports presented by members of the Cooperative Committee.

11:00–12:00 General discussion.

12:00 Adjournment of Conference.

CONFERENCE PARTICIPANTS

Name	*Address*	*Organization*
AHRENDT, M. H.	Washington, D. C.	National Council of Teachers of Mathematics.
ALLEN, OTIS W.	Greenwood, Miss.	Greenwood High School, Ford Foundation Fellowship.
ALLEN, ROWANNETTA S.	Washington, D. C.	Board of Education, Prince Georges County.
ARCHER, ALLENE	Richmond, Va.	Thomas Jefferson High School.
ARMSBY, HENRY H.	Washington, D. C.	Office of Education.
ASHFORD, THEO A.	St. Louis, Mo.	St. Louis University, American Chemical Society.

Name	Address	Organization
AUERBACH, M. L.	Richmond, Va.	John Marshall High School.
BATISTE, MARY	Washington, D. C.	National Science Teachers Association.
BEHNKE, JOHN A.	Washington, D. C.	American Association for the Advancement of Science.
BETTS, BARBARA B.	Boston, Mass.	D. C. Heath & Co.
BLACKISTON, NANETTE R.	Baltimore, Md.	Baltimore City Department of Education.
BLAYDES, GLENN W.	Columbus, Ohio.	Botanical Society of America.
BROWN, ANNIE SUE	Atlanta, Ga.	Atlanta Board of Education.
BROWN, HUGH	Chicago, Ill.	National Science Teachers Association.
BROWN, KENNETH E.	Washington, D. C.	Office of Education.
BROWN, WILLIS C.	Washington, D. C.	Office of Education.
BUCHTA, J. W.	Minneapolis, Minn.	Cooperative Committee, American Institute of Physics.
BURDETTE, MAXWELL E.	Damascus, Md.	Montgomery County Board of Education.
CARLETON, ROBERT H.	Washington, D. C.	National Science Teachers Association.
CHASE, JOHN B.	Charlottesville, Va.	University of Virginia.
CLARK, JOHN R.	Lahaska, Pa.	Columbia University.
CLEMENT, WILLIAM J.	Bridgehampton, N. Y.	Ford Foundation Fellowship.
CORNELL, RUTH E.	Wilmington, Del.	Wilmington Public Schools.
CURTIS, FRANCIS D.	Ann Arbor, Mich.	Cooperative Committee.
DAVIS, WATSON	Washington, D. C.	Science Service.
DOWNING, LEWIS K.	Washington, D. C.	D. C. Council of Engineering.
DROBKA, FRANK J.	Washington, D. C.	Catholic University of America.
DUREN, WILLIAM L.	Washington, D. C.	National Science Foundation.
ELICKER, PAUL E.	Washington, D. C.	National Association of Secondary School Principals.
EVANS, HUBERT M.	New York, N. Y.	Columbia University.
FEHR, HOWARD F.	New York, N. Y.	Columbia University.
FINDLEY, NELL GREEN	Canyon, Tex.	Canyon High School.
FINDLEY, WARREN G.	Princeton, N. J.	Educational Testing Service.
FISCHELIS, ROBERT P.	Washington, D. C.	American Pharmaceutical Association.
GAGER, WILLIAM A.	Gainesville, Fla.	University of Florida.
GETTY, JAMES	Narberth, Pa.	High School Science Teacher.
GLADIEUX, ROLLAND J.	Kenmore, N. Y.	Senior High School.
GLASHEEN, GEORGE L.	Washington, D. C.	U. S. Atomic Energy Commission.
GOODEN, JULIUS H.	Bowie, Md.	Maryland State Teachers College.
GORDON, GARFORD	Los Angeles, Calif.	University of Southern California.
GORDON, ROBERT B.	West Chester, Pa.	Cooperative Committee.
GRANT, CHARLOTTE L.	Oak Park, Ill.	National Science Teachers Association.
GREEN, L. C.	Washington, D. C.	Selective Service.
GREEN, RUTH LEE	Wilmington, Del.	P. S. du Pont High School.
GRUBBS, ETHEL H.	Washington, D. C.	D. C. Public Schools.

Name	Address	Organization
HADSALL, LEO F.	Fresno, Calif.	National Association of Biology Teachers.
HALE, HELEN E.	Towson, Md.	Baltimore County Board of Education.
HAMILTON, ALLEN T.	Washington, D. C.	Office of Education.
HAMILTON, MARGARET E.	Frostburg, Md.	State Teachers College.
HARLOW, JAMES G.	Norman, Okla.	University of Oklahoma.
HARTMANN, G. K.	White Oak, Md.	Naval Ordnance Laboratory.
Hawkins, George E.	La Grange, Ill.	Cooperative Committee.
HAYNES, EUPHEMIA L.	Washington, D. C.	Miner Teachers College.
HERBERT, AGNES.	Baltimore, Md.	National Council of Teachers of Mathematics.
HERNICK, MICHAEL E.	Washington, D. C.	Oxon Hill High School.
HILDEBRANDT, E. H. C.	Evanston, Ill.	The Mathematics Teacher.
HILL, JULIAN W.	Wilmington, Del.	E. I. du Pont de Nemours and Company.
HOGAN, RALPH M.	Washington, D. C.	Navy Department.
JOHNSON, DONOVAN A.	Minneapolis, Minn.	National Council of Teachers of Mathematics.
JOHNSON, KEITH C.	Washington, D. C.	D. C. Public Schools.
JOHNSON, PHILIP G.	Washington, D. C.	Office of Education.
JONES, BERNADINE M.	Silver Spring, Md.	Montgomery County Schools.
KINNEY, DOUGLAS M.	Washington, D. C.	American Geological Institute.
KIZER, FRANKLIN D.	Norfolk, Va.	Norfolk County Public Schools
KLEIN, T. S.	Washington, D. C.	Suitland High School.
KLINGE, PAUL.	Indianapolis, Ind.	Howe High School.
KOZAK, ANDREW V.	Athens, W. Va.	Concord State College, State Board of Education.
KRAEGEL, LOWELL G.	Washington, D. C.	National Science Foundation.
KRAUS, JOSEPH H.	Washington, D. C.	National Science Fair.
LANKFORD, F. G.	Charlottesville, Va.	University of Virginia.
LAPE, RICHARD H.	Snyder, N. Y.	Amherst Central High School.
LAZAR, NATHAN.	Columbus, Ohio.	Ohio State University.
LENTZ, DONALD W.	Parma, Ohio.	Cooperative Committee.
LEFLER, R. W.	LaFayette, Ind.	Purdue University.
LEVIN, M. JASTROW.	Baltimore, Md.	Ford Foundation Fellowship.
LLOYD, DANIEL B.	Washington, D. C.	Wilson Teachers College.
LUTZ, MARY E.	New Brunswick, N. J.	New Jersey Science Teachers Association.
LYNAM, LELA A.	Wilmington, Del.	Secondary Schools of Wilmington.
LYONS, LOUISE.	Steubenville, Ohio.	Public Schools.
McPHERSON, A. T.	Washington, D. C.	National Bureau of Standards.
MALLINSON, GEORGE G.	Kalamazoo, Mich.	National Association for Research in Science Teaching and Cooperative Committee.
MARTH, ELLA.	Washington, D. C.	Wilson Teachers College.
MAYOR, JOHN.	Madison, Wis.	Mathematics Association of America.
MEARS, FLORENCE M.	Washington, D. C.	George Washington University.
MEISTER, MORRIS.	New York, N. Y.	Cooperative Committee.
MUSIAL, JOSEPH W.	New York, N. Y.	King Features Syndicate.

Name	Address	Organization
NEIVERT, SYLVIA.....	Far Rockaway, N. Y...	Far Rockaway High School.
NELSON, CLARENCE H..	East Lansing, Mich....	Michigan State College.
NELSON, CLIFFORD R...	Centre Newton, Mass...	City of Newton and Science Teachers of N. E.
NEVILLE, ESTHER S....	Fort Lee, N. J.....	Ford Foundation Fellowship.
NEWKIRK, C. H.....	Washington, D. C.....	U. S. Air Force.
O'CONNELL, GILBERT P.	Detroit, Mich.....	General Motors.
PALMER, ELRA M.....	Baltimore, Md.....	Baltimore City Department of Education.
PATTERSON, MARGARET..	Washington, D. C.....	Science Clubs of America.
PELLEY, ALBERT L.....	Washington, D. C.....	Office of Education.
PIERCE, STANLEY, H....	Urbana, Ill.....	University of Illinois.
PINETTE, MATTIE A.....	Washington, D. C.....	Atomic Energy Commission.
ROULTON, J. E.....	Washington, D. C.....	International Association of Machinists.
QUILL, LAURENCE L....	East Lansing, Mich....	Cooperative Committee.
RAYFORD, PERCY J.....	Washington, D. C.....	D. C. Public Schools.
READ, W. T.....	Washington, D. C.....	D. C. Council Engineering Societies.
REES, MINA.....	Washington, D. C.....	Office of Naval Research.
REICHARD, HERBERT H..	Allentown, Pa.....	Allentown School District.
ROBERTS, EUGENE.....	San Francisco, Calif....	Ford Foundation Fellowship.
ROGERS, MARY C.....	Westfield, N. J.....	Westfield Junior High School.
SCHULF, VERYL.....	Washington, D. C.....	Wilson Teachers College.
SCOTT, R. WALKER.....	Washington, D. C.....	Department of the Army.
SHANNON, HENRY.....	Raleigh, N. C.....	State Department of Education.
SHUSTER, C. N.....	Trenton, N. J.....	New Jersey Teachers College.
SINCLAIR, THOMAS J.....	Washington, D. C.....	Association of American Railroads.
SKOLNIK, DAVID.....	Newark, N. J.....	Central High School.
SMITH, HERBERT R.....	Baltimore, Md.....	Baltimore Polytechnic Institute.
SORUM, C. H.....	Madison, Wis.....	Cooperative Committee.
STANERSON, B. R.....	Washington, D. C.....	American Chemical Society.
STARK, L. M.....	Pittsburgh, Pa.....	Westinghouse Electric Co.
STEWART, NATHANIEL...	Washington, D. C.....	Department of the Navy.
STRAWCUTTER, RICHARD.	Wilton, Conn.....	Wilton Schools.
SUBARSKY, ZACHARIAH..	Bronx, N. Y.....	High School of Science.
TAYLOR, S. LEROY.....	Baltimore, Md.....	Department of Education.
TEMPLETON, HUGH.....	Albany, N. Y.....	State Education Department, American Association for Gifted Children.
TORREY, MARIAN M....	Towson, Md.....	Goucher College.
TURNER, ETHEL M.....	Bowie, Md.....	Maryland State Teachers College.
VAN DUSEN, EDWARD B.	Pittsfield, Mass.....	Technical High School.
WANTLING, DALE.....	Knoxville, Tenn.....	University of Tennessee.
WARINNER, W. F.....	Richmond, Va.....	John Marshall High School.
WATSON, BERNARD B...	Washington, D. C.....	Cooperative Committee.
WEAGLY, LOUISE A.....	Middletown, Md.....	Ford Foundation Fellowship.

Name	Address	Organization
WETLAUFER, L. A.....	Wilmington, Del.....	E. I du Pont de Nemours & Co.
WHITAKER, PREVO L....	Bloomington, Ind.....	Cooperative Committee.
WILLIAMS, S. K.....	Washington, D. C.....	Monsanto Chemical Co.
WINTON, HAROLD M....	New York, N. Y.....	National Electrical Manufacturers' Association.
WISE, HAROLD E.....	Lincoln, Nebr.....	University of Nebraska.
ZIM, HERBERT S.....	Urbana, Ill.....	University of Illinois.